ADDITIONAL SERIES LINES IN THE SPECTRA OF C II AND N II

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Abstract

Several of the strong lines of C II have been identified as combinations of the ^4P term of the sp^2 configuration with the quartet terms observed by Fowler and Selwyn. This fixes the term values $^4P_1=206810.7$, $^4P_2=206789.2$, $^4P_3=206760.6$. In N II, the term value of the ^1S term of the s^2p^2 configuration, has been fixed at 206159, and of the ^1P term of the sp^3 configuration at 72084 relative to the term values given by Fowler and Freeman. The ^1S term combines with the ^1D term of the same configuration to give the nebular line at 5754.8A. A large number of terms including those which Fowler and Freeman designated by "a" have been shown to belong to the quintet system. These have the following relative term values: sp^2s, $^5P_1=90000$, $^5P_2=89943.8$, $^5P_3=89873.1$; $sp^2\cdot p$, $^5S=65759.0$, $^5P_1=69994.5$, $^5P_2=69970.7$, $^5P_3=69926.9$, $^5D_0=71955.0$, $^5D_1=71939.8$, $^5D_2=71909.6$, $^5D_3=71866.5$, $^5D_4=71812.6$; $sp^2\cdot d$, $^5D_1=50658.5$, $^5D_2=50650.6$, $^5D_3=50639.3$ $^5D_4=50624.9$, $^5F_2=52611.4$, $^5F_3=52585.3$, $^5F_4=52551.6$, $^5F_5=52511.1$; sp^3, $^5S=248812(?)$.

Spectra of C II

IN THEIR recent analysis of the C II spectrum, Fowler and Selwyn[1] have fixed all of the important doublet terms and most of the high level quartet terms. However, the lowest term in the quartet system, namely, the b^4P term of the sp^2 configuration, was not located. Table I lists several multiplets that represent combinations between the previously identified high level terms and this b^4P term. This gives the term values shown in the table, relative to Fowler and Selwyn's quartet system.

Table I. *Multiplets in C II.*

Int.	λ	ν	Series designation	Term values
2	641.62	155855.	$b^4P_{1,1,2}-3d^4P_{1,2,1}$	b^4P_1 206810.7
3	641.84	155802.	$b^4P_{2,3,3}-3d^4P_{3,2,3}$	b^4P_2 206789.2
				b^4P_3 206760.6
4	651.36	153525.	$b^4P\quad -3d^4D$	
				c^4S 107788.1
5	806.400	124007.9	$b^4P_2\quad -3s^4P_3$	
5	806.570	123981.8	$b^4P_{1,3}\quad -3s^4P_{2,3}$	
4	806.862	123936.9	$b^4P_{2,3}\quad -3s^4P_{1,2}$	

Unfortunately, no inter-combinations between the doublet and quartet system have been identified. This makes it impossible to fix accurately one system of values relative to the other. The relation between the two systems is particularly uncertain in this case as all of the known doublet series converge to the 2^1S term of the C^{++} ion, while all of the quartet series converge

[1] Fowler and Selwyn, Proc. Roy. Soc. **A120**, 312 (1928).

to the 2^3P term. This difference is also uncertain because of the failure to find inter-combinations in C III. However, a study of the C III spectrum indicates that the difference between these terms is of the order of 34000 cm^{-1}. If this value is assumed, then the difference between a^2P of s^2p and b^4P of sp^2 is $34000+196659-206811=23848$. This may be in error by as much as 5000 cm^{-1} however.

The inter-combination multiplet (a^2P-b^4P), arising from a transition between these terms, is practically forbidden in a light element such as carbon and, therefore, it has never been observed in a terrestrial source. However, it should appear under nebular conditions and it may be partially represented in the nebular spectrum by some of the unidentified faint lines near 4700A, as some of the expected frequency separations appear in this group.

TABLE II. *Multiplits in N II.*

Int.	λ Vac.	ν	Series Designation	Int.	λ Air	ν	Series Designation
1	475.88	210137.	a_3P-4d^3D	0	4712.13	21215.91	$3p^5D_3-3d^5D_2$
				2	4718.43	21187.58	$3p^5D_4-3d^5D_4$
2	529.37	188904.	$a^3P_{1,0}-3d^3P_{0,1}$	0	4721.59	21173.40	$3p^5D_4-3d^5D_3$
2	529.63	188811.	$a^3P_1-3d^3P_2$				
2	529.83	188740.	$a^3P_2-3d^3P_2$	2	4991.22	20029.61	$3s^5P_1-3p^5P_2$
				0	4997.23	20005.52	$3s^5P_1-3p^5P_1$
3	582.157	171775.0	a^1D-3d^1D	2	5012.026	19946.46	$3s^5P_{3,2}-3p^5P_{3,1}$
				2	5023.11	19902.45	$3s^5P_3-3p^5P_2$
2	629.19	158935.	$b^5S-3s^5P_3$				
2	629.44	158871.	$b^5S-3s^5P_2$	1	5168.24	19343.57	$3p^5P_1-3d^5D_2$
				1	5170.08	19336.61	$3p^5P_1-3d^5D_1$
2	635.20	157430.7	a^1S-3d^1P	1	5171.46	19331.53	$3p^5P_2-3d^5D_3$
				1	5172.32	19328.32	$3p^5D_1-3d^5F_2$
3	660.291	151448.4	a^1D-b^1P	2	5173.37	19324.39	$3p^5D_2-3d^5F_3$
				1	5174.46	19320.32	$3p^5P_2-3d^5D_2$
3	745.839	134077.2	a^1S-b^1P	3	5175.89	19314.98	$3p^5D_3-3d^5F_4$
				5	5179.50	19301.52	$3p^5D_4-3d^5F_5$
4	746.989	133870.8	a^1D-3s^1P	2	5183.21	19287.71	$3p^5P_3-3d^5D_3$
	Air			2	5184.97	19281.16	$3p^5D_3-3d^5F_3$
1	4124.10	24240.90	$3s^5P_1-3p^5S$	2	5190.42	19260.91	$3p^5D_4-3d^5F_4$
2	4133.654	24184.87	$3s^5P_2-3p^5S$	00	5199.53	19227.17	$3p^5D_4-3d^5F_3$
3	4145.759	24114.26	$3s^5P_3-3p^5S$				
				2	5526.26	18090.41	$3s^5P_1-3p^5D_2$
1	4695.91	21289.19	$3p^5D_1-3d^5D_2$	4	5530.27	18077.29	$3s^5P_2-3p^5D_3$
0	4700.12	21270.12	$3p^5D_2-3d^5D_3$	5	5535.39	18060.57	$3s^5P_3-3p^5D_4$
0	4702.57	21259.04	$3p^5D_2-3d^5D_2$	1	5540.16	18045.02	$3s^5P_1-3p^5D_0$
0	4704.33	21251.09	$3p^5D_2-3d^5D_1$	3	5543.49	18034.18	$3s^5P_2-3p^5D_2$
0	4706.41	21241.70	$3p^5D_3-3d^5D_4$	3	5551.95	18006.70	$3s^5P_3-3p^5D_3$
				0	5565.30	17963.51	$3s^5P_3-3p^5D_2$

Term Values

a^1D	223529	$3p^5S$	65759.0	$3d^5D_1$	50658.5
				$3d^5D_2$	50650.6
a^1S	206157	$3p^5P_1$	69994.6	$3d^5D_3$	50639.3
		$3p^5P_2$	69970.7	$3d^5D_4$	50624.9
		$3p^5P_3$	69926.9		
				$3d^5F_2$	52611.4
		$3p^5D_0$	71955.0	$3d^5F_3$	52585.3
		$3p^5D_1$	71939.8	$3d^5F_4$	52551.6
$3s^5P_1$	90000.0	$3p^5D_2$	71909.6	$3d^5F_5$	52511.1
$3s^5P_2$	89943.8	$3p^5D_3$	71866.5		
$3s^5P_3$	89873.1	$3p^5D_4$	71812.6		
				b^5S	248812.

SPECTRA OF N II

Fowler and Freeman[2] analyzed the triplet and singlet systems of N II but they failed to locate the a^1S and a^1D terms of the s^2p^2 configuration. The identification[3] of the 6548 and 6583 nebular lines fixed the a^1D term and

[2] Fowler and Freeman, Proc. Roy. Soc. **A114,** 662 (1927).

[3] Bowen, Astrophys. J. **67,** 1 (1928).

Becker and Grotian's[4] provisional identification of the 5755 line from its behavior in the nebulae indicated the position of the a^1S term. If we assume these values, we can at once predict the position of the lines arising from the combinations between these terms and the high level singlet terms found by Fowler and Freeman. The observed lines, identified by their close agreement with the predictions, are given in Table II. As the deviations between the predicted and observed wave-lengths are in every case well within the experimental error, little doubt remains as to the correctness of the identification of these nebular lines.

Fowler and Freeman did not locate any of the quintet terms that appear when one of the s electrons is excited. However, several multiplets were found and designated with an a, which they thought were triplets, although they were unable to fit them into the general N II system of terms. Further study shows that other lines in the region of these multiplets belong to them and that they are in reality quintets. These completed multiplets along with several additional multiplets belonging to the same quintet system are listed in Table II. All of the wave-lengths above 2000A are taken from Fowler and Freeman, while the shorter wave-lengths represent new determinations The preceding small letters and numbers indicate the position of the excited electron.

The term values of the singlet terms are relative to Fowler and Freeman's system. The quintet terms are independently fixed, as no inter-combinations have been found. They differ from the values of the triplets and singlets by approximately the amount that b^4P of the sp^2 configuration of N III differs from the a^2P term of s^2p configuration, as these are the terms to which the respective series converge.

[4] Becker and Grotrian, Ergebnisse der Exackten Naturwissenschaften, **7**, 65 (1928).